

What is claimed is:

- 1 1. A method of increasing combustion of a hydrocarbon fuel in a combustion
2 chamber, the combustion normally using only air as an oxidant, part of the air entering the
3 combustion chamber near one or more hydrocarbon fuel burners, and a remaining portion of
4 air entering the combustion chamber at a plurality of locations downstream of said
5 hydrocarbon fuel burners, the method comprising the steps of injecting an oxygen-enriched
6 gas at a velocity through a plurality of lances into a flue gas in the combustion chamber at
7 said plurality of locations downstream of said burners, the oxygen-enriched gas being present
8 in an amount sufficient to provide an oxygen concentration in the flue gas of no more than
9 2% on a volume basis greater than when said air is used alone as said oxidant.
- 1 2. Method in accordance with claim 1 wherein said velocity is subsonic for said
2 oxygen-enriched gas in each of said plurality of lances.
- 1 3. Method in accordance with claim 1 wherein some of said oxygen-enriched gas
2 is injected at subsonic velocity in one or more of said plurality of lances while a balance of
3 said oxygen-enriched gas is injected at supersonic velocity through a balance of said plurality
4 of lances.
- 1 4. Method in accordance with claim 1 wherein said velocity is supersonic for
2 said oxygen-enriched gas in each of said plurality of lances.
- 1 5. Method in accordance with claim 1 wherein some of said oxygen-enriched gas
2 is injected at subsonic velocity in one or more of said lances while a balance of said oxygen-
3 enriched gas is injected at supersonic velocity through one or more of said lances.
- 1 6. Method in accordance with claim 1 wherein said lances inject said oxygen-
2 enriched gas at an angle with respect to a wall of the combustion chamber, said angle ranging
3 from about 20° to about 160°, said angle measured in a plane that is perpendicular to the wall.

1 7. Method in accordance with claim 1 wherein said plurality of locations are
2 arranged so that one-half of said lances are on a first wall of said combustion chamber and
3 one-half of said lances are on a second wall of said combustion chamber, said first and
4 second walls being substantially parallel.

1 8. Method in accordance with claim 7 wherein said lances on said first wall are
2 separated by a distance L_L , wherein $L_L < L_{CH} / 2$, wherein L_{CH} is selected from the group
3 consisting of height, length, and width of the combustion chamber.

1 9. Method in accordance with claim 8 wherein said lances on said first wall are
2 positioned a distance l from said lances on said second wall, wherein $0 < l < L_L / 2$, wherein
3 L_L is the distance between lances on said first wall.

1 10. Method in accordance with claim 1 wherein the combustion chamber is
2 rectangular having four walls.

1 11. Method in accordance with claim 10 wherein there is at least one lance on
2 each of said four walls of said rectangular combustion chamber.

1 12. Method in accordance with claim 11 wherein each lance is a distance L' from
2 a wall wherein an adjacent lance is positioned, and $L' < L_{CH}$, wherein L_{CH} is selected from the
3 group consisting of height, length, and width of the combustion chamber.

1 13. Method in accordance with claim 11 wherein each lance is positioned at a first
2 angle ranging from about 20° to about 160° , said first angle measured in a first plane which is
3 substantially vertical and substantially perpendicular to its corresponding wall.

1 14. Method in accordance with claim 13 wherein each lance is positioned at a
2 second angle ranging from about 20° to about 160° , said second angle measured in a plane
3 substantially perpendicular to the first plane.

1 15. Method in accordance with claim 1 wherein the remaining portion of air enters
2 the combustion chamber through one or more rectangular slots, at least one of said lances
3 positioned in each of said rectangular slots.

1 16. Method in accordance with claim 1 wherein the remaining portion of air enters
2 the combustion chamber through one or more substantially circular slots, at least one of said
3 lances positioned in each of said substantially circular slots.

1 17. Method in accordance with claim 1 wherein the oxygen-enriched gas is
2 injected in substitution for said remaining portion of air at at least one of said plurality of
3 downstream locations.

1 18. Method in accordance with claim 1 wherein said oxygen-enriched gas is
2 injected into said remaining portion of air.

1 19. A method of increasing combustion of coal in a combustion chamber, the
2 combustion normally using only air as an oxidant, part of the air entering the combustion
3 chamber near one or more coal burners, and a remaining portion of air entering the
4 combustion chamber at a plurality of locations downstream of said coal burners, the method
5 comprising the steps of injecting an oxygen-enriched gas at a velocity through a plurality of
6 lances into a flue gas in the combustion chamber at said plurality of locations downstream of
7 said burners, the oxygen-enriched gas being present in an amount sufficient to provide an
8 oxygen concentration in the flue gas of no more than 2% on a volume basis greater than when
9 said air is used alone as said oxidant.

1 20. Method in accordance with claim 19 wherein said velocity is subsonic for said
2 oxygen-enriched gas in each of said plurality of lances.

1 21. Method in accordance with claim 19 wherein said velocity is supersonic for
2 said oxygen-enriched gas in each of said plurality of lances.

1 22. Method in accordance with claim 19 wherein some of said oxygen-enriched
2 gas is injected at subsonic velocity in one or more of said plurality of lances while a balance
3 of said oxygen-enriched gas is injected at supersonic velocity through a balance of said
4 plurality of lances.

1 23. Method in accordance with claim 19 wherein the oxygen-enriched gas is
2 injected through said lances at an angle with respect to a wall of the combustion chamber,
3 said angle ranging from about 20° to about 160°, said angle measured in a plane that is
4 perpendicular to the wall.

1 24. Method in accordance with claim 19 wherein said plurality of locations are
2 arranged so that one-half of said lances are on a first wall of said combustion chamber and
3 one-half of said lances are on a second wall of said combustion chamber, said first and
4 second walls being substantially parallel.

1 25. Method in accordance with claim 24 wherein lances on said first wall are
2 separated by a distance L_L , wherein $L_L < L_{CH} / 2$, wherein L_{CH} is selected from the group
3 consisting of height, length, and width of the combustion chamber.

1 26. Method in accordance with claim 24 wherein said lances on said first wall are
2 positioned a distance l from said lances on said second wall, wherein $0 < l < L_L / 2$, wherein
3 L_L is the distance between lances on said first wall.

1 27. Method in accordance with claim 19 wherein the combustion chamber is
2 rectangular having four walls.

1 28. Method in accordance with claim 27 wherein there is at least one lance on
2 each of said four walls of said rectangular combustion chamber.

1 29. Method in accordance with claim 28 wherein each lance is a distance L' from
2 a wall wherein an adjacent lance is positioned, and $L' < L_{CH}$, wherein L_{CH} is selected from
3 the group consisting of height, length, and width of the combustion chamber.

1 30. Method in accordance with claim 28 wherein each lance is positioned at a first
2 angle ranging from about 20° to about 160° , said first angle measured in a first plane which is
3 substantially vertical and substantially perpendicular to its corresponding wall.

1 31. Method in accordance with claim 30 wherein each lance is positioned at a
2 second angle ranging from about 20° to about 160° , said second angle measured in a plane
3 substantially perpendicular to the first plane.

1 32. Method in accordance with claim 19 wherein the remaining portion of air
2 enters the combustion chamber through one or more rectangular slots, at least one of said
3 lances positioned in each of said rectangular slots.

1 33. Method in accordance with claim 19 wherein the remaining portion of air
2 enters the combustion chamber through one or more substantially circular slots, at least one
3 of said lances positioned in each of said substantially circular slots.

1 34. Method in accordance with claim 19 wherein the oxygen-enriched gas is
2 injected in substitution for said remaining portion of air at at least one of said plurality of
3 downstream locations.

1 35. Method in accordance with claim 19 wherein said oxygen-enriched gas is
2 injected into said remaining portion of air.

1 36. A method of increasing combustion of a first hydrocarbon fuel in a
2 combustion chamber, the combustion normally using only air as an oxidant, part of the air
3 entering the combustion chamber through one or more first hydrocarbon fuel burners in a first

4 zone of the combustion chamber, and a remaining portion of air normally entering the
5 combustion chamber at a plurality of locations downstream of said first hydrocarbon fuel
6 burners, the method comprising injecting a first oxygen-enriched gas into the combustion
7 chamber at said plurality of locations, the first oxygen-enriched gas being in an amount
8 sufficient to provide an oxygen concentration of no more than 2% greater than when said air
9 is used alone, and wherein the first oxygen-enriched gas is injected through a lance at a
10 velocity, said lance injecting said first oxygen-enriched gas into a flame created by a second
11 oxygen-enriched gas and a second hydrocarbon fuel.

1 37. Method in accordance with claim 36 wherein said velocity is subsonic.

1 38. Method in accordance with claim 36 wherein said velocity is supersonic.

1 39. Method in accordance with claim 36 wherein said second hydrocarbon fuel is
2 selected from the group consisting of gaseous, liquid, and particulate fuels.

1 40. Method in accordance with claim 36 wherein said second oxygen-enriched gas
2 has substantially the same concentration of oxygen as said first oxygen-enriched gas.

1 41. Method in accordance with claim 36 wherein each lance is positioned at a first
2 angle ranging from about 20° to about 160°, said first angle measured in a first plane which is
3 substantially vertical and substantially perpendicular to its corresponding wall.

1 42. Apparatus for combustion of a hydrocarbon fuel in a combustion chamber, the
2 combustion normally using only air as an oxidant, part of the air entering the combustion
3 chamber near one or more hydrocarbon fuel burners, and a remaining portion of air entering
4 the combustion chamber at a plurality of locations downstream of said hydrocarbon fuel
5 burners, the method comprising the steps of injecting an oxygen-enriched gas at a velocity
6 through a plurality of lances into a flue gas in the combustion chamber at said plurality of
7 locations downstream of said burners, the oxygen-enriched gas being present in an amount

8 sufficient to provide an oxygen concentration in the flue gas of no more than 2% on a volume
9 basis greater than when said air is used alone as said oxidant.

1 43. Apparatus in accordance with claim 42 wherein said lances allow injection of
2 said oxygen-enriched gas at sub-sonic velocity.

1 44. Apparatus in accordance with claim 42 wherein said lances allow injection of
2 said oxygen-enriched gas at supersonic velocity.

1 45. Apparatus in accordance with claim 42 wherein each lance is positioned at a
2 first angle ranging from about 20° to about 160°, said first angle measured in a first plane
3 which is substantially vertical and substantially perpendicular to its corresponding wall.

1 46. Apparatus for combustion of a hydrocarbon fuel in a combustion chamber, the
2 combustion normally using only air as an oxidant, part of the air entering the combustion
3 chamber through one or more first hydrocarbon fuel burners in a first zone of the combustion
4 chamber, and a remaining portion of air normally entering the combustion chamber at a
5 plurality of locations downstream of said first hydrocarbon fuel burners, the method
6 comprising injecting a first oxygen-enriched gas into the combustion chamber at said
7 plurality of locations, the first oxygen-enriched gas being in an amount sufficient to provide
8 an oxygen concentration of no more than 2% greater than when said air is used alone, and
9 wherein the first oxygen-enriched gas is injected through a lance at a velocity, said lance
10 injecting said first oxygen-enriched gas into a flame created by a second oxygen-enriched gas
11 and a second hydrocarbon fuel.

1 47. Apparatus in accordance with claim 46 wherein said lance allows injection of
2 said oxygen-enriched gas at sub-sonic velocity.

1 48. Apparatus in accordance with claim 46 wherein lance allows injection of said
2 oxygen-enriched gas at supersonic velocity.

1 49. Apparatus in accordance with claim 46 wherein said lance is positioned at a
2 first angle ranging from about 20° to about 160°, said first angle measured in a first plane
3 which is substantially vertical and substantially perpendicular to its corresponding wall.

1 50. Apparatus in accordance with claim 46 wherein said lance is positioned at a
2 first angle ranging from about 45° to about 135°, said first angle measured in a first plane
3 which is substantially vertical and substantially perpendicular to its corresponding wall.